OCEAN COLOR 2019

The 7th Asian/16th Korea-Japan Workshop on Ocean Color
(7th AWOC/16th KJWOC)

December 11 - 14, 2019

Faculty of Science,Burapha University Chonburi, Thailand

APN

JAMSTEC
Department of Environmental and Geochemical Cycle Research

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NAGOYA UNIVERSITY
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INSTITUTE FOR SPACE-EARTH ENVIRONMENTAL RESEARCH

The 7th Asian/16th Korea-Japan Workshop on Ocean Color
(7th AWOC/16th KJWOC)
11 – 14 December 2019
Room CL101 Central Laboratory Building
Faculty of Science, Burapha University, Thailand

Workshop Schedule (Tentative)

11 December 2019

Time	**Programs**
8:30 – 9:30	Registration
9:30 – 10:00	Welcome remarks
10:00 – 10:30	Group photos and coffee break
10:30 – 11:30	**Session 1 -** *Chair: Eko Siswanto, Co-chair: Siraporn Tong-u-dom*
O-01-01	Current status of GOCI-II Ground Segment Development and In-Orbit Test plan of GOCI-II ***Hee-Jeong Han****, Jae-Moo Heo, Hyun Yang, Woo-Chang Choi Joo-Hyung Ryu, Young-Je Park*
O-01-02	Multi-year analysis of GOCI products in comparison with MODIS and VIIRS *Seonju Lee,* ***Myung-Sook Park****, Sunju Lee, Jae-Hyun Ahn*
O-01-03	Initial validation of GCOM-C SGLI ocean products in Tokyo Bay ***Yuji Sakuno****, Hiroto Higa, Hiroshi Kobyashi*
11:30 – 13:00	Lunch
13:00 – 14:30	**Session 2 -** *Chair: Young Baek Son, Co-chair: Mengmeng Yang*
O-02-01	Status of SGLI/GCOM-C and AHI/Himawari-8 ***Joji Ishizaka****, Hiroshi Murakami, Kazunori Ogata, Mitsuhiro Toratani*
O-02-02	Development and current status of the GOCI-II atmospheric correction algorithm ***Jae-Hyun Ahn****, Young-Je Park*
O-02-03	Improvement of atmospheric correction scheme for SGLI ocean color data ***Mitsuhiro Toratani****, Kota Katano, Masahiro Konno, Kazunori Ogata*
O-02-04	Development of an Atmospheric Correction Method by Considering Inherent Optical Properties for a Specified Coastal Area ***Taiga Nakayama****, Hiroto Higa, Kazunori Ogata, Mitsuhiro Toratani, Salem Ibrahim Salem*
14:30 – 15:00	Coffee break
15:00 – 16:30	**Session 3 -** *Chair: Mitsuhiro Toratani, Co-chair: Jutarak Luang-on*
O-03-01	Elucidating Back-Scattering Properties in Coastal Areas and Lakes by using Hydroscat-6p and Radiative Transfer Simulation ***Hiroto Higa****, Hidehito Taki, Salem Ibrahim Salem*
O-03-02	Development of algorithm for detecting low-salinity plume in the East China Sea during the summer using GOCI ***Young Baek Son****, Joo-Hyung Ryu, Jong Kuk Choi, Kyeong-Hong Kim*
O-03-03	Attempts to improve the simulation of phytoplankton absorption spectra for various trophic statuses ***Salem Ibrahim Salem****, Hiroto Higa, Joji Ishizaka and Kazuo Oki*
O-03-04	Development of bio-optical model considering the variation in dominant species of phytoplankton by hierarchical clustering ***Kanako Fujita****, Hiroto Higa, Salem Ibrahim Salem*

16:30 – 17:30	Free time
17:30 – 22:00	Scientific networking and welcome party

12 December 2019

Time	Programs
8:30 – 10:00	**Session 4 -** *Chair: Genki Terauchi, Co-chair: Tawatchai Na-u-dom*
O-04-01	Characterization of absorption and attenuation coefficients and their relationship with Chl-a in the southeastern Arabian Sea ***Kumaraswami Munnoor**, Sisir Kumar Dash, Karri Ramu Vinjamuri Ranga Rao and M. V. Ramana Murthy*
O-04-02	Tracing sea surface warming and cooling in the East China Sea during summer ***Gwang Seob Park**, Yong Baek Son*
O-04-03	Spatial variability of fishing grounds over oceanic front changes detected by multiple satellite measurements in the East (Japan) Sea ***Young-Heon Jo**, Dae-won Kim, Yejin Oh, Jae-Dong Hwang, Chu-Yong Chung*
O-04-04	Estimation of hourly sea surface salinity in the East China Sea using Geostationary Ocean Color Imager measurements ***Dae-won Kim**, Young-Je Park, Jin-Young Jeong, and Young-Heon Jo*
10:00 – 10:30	Coffee break
10:30 – 11:30	**Session 5 -** *Chair: Young-Heon Jo, Co-chair: Phattaranakorn Nakornsantiphap*
O-05-01	Imprints of Indian Ocean Dipole on surface circulation and Chlorophyll and Oxygen distributions of the Arabian Sea- A remote sensing perspective ***Benny N Peter**, Meenakshi Sreejith, Eko Siswanto*
O-05-02	The decadal trend and seasonal patterns of the surface chlorophyll-a in 12 Large Marine Ecosystems in the North Pacific ***Sinjae Yoo**, Christina Eunjin Kong*
O-05-03	Variability of Satellite Chlorophyll a over the Spring Neap Tidal Cycle in the Turbid Ariake Bay, Japan ***Mengmeng Yang**, Joji Ishizaka, Joaquim I. Goes Tian Hongzhen, Elígio R. Maúre*
11:30 – 13:00	Lunch
13:00 – 14:30	Poster presentations
14:30 – 15:00	Coffee break
15:00 – 16:30	**Session 6 -** *Chair: Wirote Laongmanee, Co-chair: Dudsadee Leenawarat*
O-06-01	Seasonal variability of green Noctiluca in the upper Gulf of Thailand ***Jutarak Luang-on**, Joji Ishizaka Anukul Buranapratheprat, Jitraporn Phaksopa*
O-06-02	The Distribution of Chlorophyll-a Concentration and Fish Catch during the Indian Ocean Dipole 2019 in the Eastern Indian Ocean off Palabuhanratu Bay ***Jonson Lumban-Gaol**, I Nyoman Metah Natih, Tri Hartanto Berri Mirraz Rahman1, Arik Permana*
O-06-03	Dynamic Forcing for the Chlorophyll Blooms off Northern Borneo ***Che Sun***
O-06-04	Seasonal and Interannual Variations of Sea Surface Chlorophyll-a in the Southern Makassar Strait Revelaed by MODIS *Riza Y. Setiawan, Anindya Wirasatriya, **Iskhaq Iskandar***

13 December 2019

Time	Programs
8:30 – 10:00	**Session 7 -** *Chair: Iskhaq Iskandar, Co-chair: Arvut Munhapon*
O-07-01	Study of Internal solitary waves and chlorophyll-a distribution patterns in Flores Sea, Indonesia using satellite data ***Chonnaniyah***, *I Wayan Gede Astawa Karang, Takahiro Osawa*
O-07-02	Assessment of phytoplankton abundance using remote sensing reflectance data and Chlorophyll-a data derived using Aqua-Modis satellite to monitor massive fish kills in the Jakarta Bay ***Sam Wouthuyzen***, *Tumpak Sidabutar, Eko Siswanto*
O-07-03	The distinction of green and golden tides using reflectivity characteristics ***Seung-Hwan Min***, *Young Baek Son*
O-07-04	Detection of seagrass beds by Google Earth Engine in western Nanao Bay ***Genki Terauchi***, *Eligio de Raús Maúre, Yasuyuki Harada* *Wataru Matsumura, Tsuneo Maeda*
10:00 – 10:30	Coffee break
10:30 – 11:30	**Session 8 -** *Chair: Hiroto Higa, Co-chair: Chonnaniyah*
O-08-01	Imprint of climate variability on Indo-Pacific ocean surface biology ***Eko Siswanto***, *Riza S. Yuliratno, Iskhaq Iskandar, Jonson L. Gaol*
O-08-02	Physiological flexibility of phytoplankton impacts modeled chlorophyll and primary production across the North Pacific ***Yoshikazu Sasai***
O-08-03	
11:30 – 13:00	Lunch
13:00 – 14:00	Discussion: Collaborations & next AWOC/KJWOC ***Eko Siswanto***
14:00 – 14:30	Closing remarks

14 December 2014

Time	Excursion Programs
07.00 – 09.30	Leave Tao-Thong Hotel for Bang Pa-In Royal Palace, Ayutthaya Province
09.30 – 11.30	Visit Bang Pa-In Royal Palace
11.30 – 12.00	Leave Bang Pa-In Royal Palace for the center of Ayutthaya
12.00 – 13.00	Lunch on a sightseeing boat sailing along the Chao Phraya River
13.00 – 13.30	Leave for Phra Si Sanphetch Temple
13.30 – 14.30	Visit Phra Si Sanphetch Temple
14.30 – 15.00	Leave for Chao Sam Phraya National Museum
15.00 – 16.00	Visit Chao Sam Phraya National Museum
16.00 – 18.00	Leave for the Great Residence near Suvarnabhumi Airport
18.00 – 20.00	The staffs return to Burapha University

Poster session

No.	Titles
P-01	Spatiotemporal variability of chlorophyll-a in the Andaman Sea (1998-2018) ***Christina Eunjin Kong***
P-02	Effect of high atmospheric Nitrogen Dioxide (NO_2) concentration on GOCI ocean color products ***Donghee Kim**, Myung-Sook Park, Jae-hyun Ahn*
P-03	Chlorophyll-a variability in the Gulf of Thailand during El Niño event from MODIS data ***Dudsadee Leenawarat**, Anukul Buranapratheprat, Joji Ishizaka*
P-04	Inherent and apparent optical properties in the Seto-Inland Sea in summer ***Eko Siswanto**, Kazuyoshi Miyamura, Joji Ishizaka*
P-05	Persistent Cloud Cover Curtails the Spring Phytoplankton Peak in the Toyama Bay ***Eligio Maure**, Genki Terauchi*
P-06	Analysis of ocean optical characteristics in the coastal waters of Yeosu in 2017 ***Eunkyung Lee**, Jeongeon Moon, Tai-hyun Han, Youngje Park*
P-07	Development of Level-2 Data Processing Software for GOCI-II ***Jae-Moo Heo**, Hee-Jeong Han, Hyun Yang*
P-08	Water Temperature Prediction and Gyroscope Signal Denoising using Deep Learning Technology ***Min-Kyu Kim**, Hyun Yang, Jong-Hwa Kim*
P-09	Look Up Table Development of Simulated In-Situ Bio-optical Dataset for Satellite Data Product Classification ***Nurul Inayah Bada Maulidya**, Hiroto Higa, Salem Ibrahim Salem, Takayuki Suzuki*
P-10	Effects of ancillary meteorological data on Rayleigh-corrected Top of the Atmosphere reflectance using GOCI data ***Sinil Yang**, Jae-Hyun Ahn, Myung-Suk Park, Young-Je Park*
P-11	Data Service Environment (DSE) for GOCI-II ground segment ***Woo Chang Choi**, Jae-Moo Heo, Suk Yoon, Hee-Jeong Han, Hyun Yang*

Oral Presentations

Current status of GOCI-II Ground Segment Development and In-Orbit Test plan of GOCI-II

Hee-Jeong Han*, Jae-Moo Heo, Hyun Yang, Woo-Chang Choi, Joo-Hyung Ryu, Young-Je Park

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Korea Ocean Satellite Center (KOSC) has developed the Geostationary ocean color imager-II (GOCI-II) with Korea Aerospace Research Institute (KARI) and Airbus D&S since 2012 and the GOCI-II Ground Segment(G2GS) since 2015. GOCI-II is assembled to the Geo-KOMPSAT 2B satellite and finished all functional tests in satellite level before launch and waiting to move to launch site. G2GS has composed 6 subsystems and it is distinguished 3 operational environments. All G2GS functions are developed for real time data processing and service of GOCI-II. Also, KOSC has establishing new operational facility including data receiving antenna in Busan, Korea.

GOCI-II will be launched in March 2020. The In-Orbit Test (IOT) of GOCI-II in KARI site will be performed to check its functionalities and performances during 6 months after its successful locating at geostationary orbital position. The radiometric calibration parameter tuning for the TOA radiance retrieval is planned in this IOT period. Also, the geometric correction parameter tuning, and validation will be performed simultaneously. To derive GOCI-II Level 1B geometric corrected data, we adopted the image navigation and registration methods using star and shore-line observation for keeping geometric correction error within 2 pixels. After that, KOSC will perform the G2GS IOT for evaluating the G2GS systems and for calibration and validation of level 2 data generated by G2GS for 4 months. GOCI-II level 1B and level 2 data will be released gradually.

Multi-year analysis of GOCI products in comparison with MODIS and VIIRS

Seonju Lee[1, 2], Myung-Sook Park[2], Sunju Lee[2], Jae-Hyun Ahn[2]

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Chlorophyll, which is indicator for the amount of phytoplankton biomass, plays the important role in marine ecosystem due to the conversion of carbon dioxide into oxygen and organic matter through photosynthesis. Geostationary Ocean Color Imager (GOCI), the world's first geostationary ocean color satellite, has launched in June 2010 and has provided the near real-time ocean color products over the East Asian Marginal Seas (EASM). GOCI covered EASM region to include diverse ocean optical features (from clear water over the northern Pacific to extremely turbid water over the Yellow Sea). Whereas the GOCI data has been applied main to short-term monitoring, it is the time to examine multi-year GOCI records to its consistency with the well-known NASA's ocean color satellites over the EAMS.

We compare the consistency of chlorophyll-a data among the GOCI, MODIS, and VIIRS on the seasonal and inter-annual variations from 2011 to 2018. Although the spatial patterns are quite similar for all three satellites, the GOCI tends to underestimate the chlorophyll-a concentration compared to MODIS and VIIRS. Considering our regional coefficients in OC3 algorithm may partly contribute to the underestimation in GOCI chlorophyll-a but other factors (atmospheric correction) will be discussed in this study.

Initial validation of GCOM-C SGLI ocean products in Tokyo Bay

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In recent years, heavy rain disasters have frequently occurred in Japan, and there is a need to monitor water quality changes with high resolution and high frequency in coastal areas. On the other hand, SGLI (Second Generation Global Imager) of GCOM-C (Global Change Observation Mission) launched in December 2017 officially began distributing general data from the end of December 2018 after a one-year validation period. SGLI sensor has the ability to measure coastal water temperature and water quality once every 2-3 days with 250-m resolution. However, the product accuracy validation in the coastal area is insufficient. Therefore, in this study, we will introduce the estimation accuracy verification results of SGLI ocean products such as SST (Sea Surface Temperature), Chl-a (Chlorophyll-a concentration), and TSM (Total Suspended Matter) immediately after distribution of general data.

The SGLI data used for the validation are SST, Chl-a, and TSM data from January to August 2019 in Tokyo Bay. These data were downloaded from JASMES (JAXA Satellite Monitoring for Environmental Studies) SGLI near real-time website. The field data used for the validation is the surface data at every hour on the hour observed by the Ministry of Land, Infrastructure, Transport and Tourism. As a result, the accuracy of SST products with a bias of 0.05 °C and a standard deviation of 0.98 °C (N = 167) was obtained when the underestimation time of 3 °C or higher was excluded. The data acquisition rate was about 20% every month. The acquisition rates in February, June, and July were very low. Chla and turbidity (TSM) data have low estimation accuracy, so it may be necessary to improve the algorithm in Tokyo Bay.

Status of SGLI/GCOM-C and AHI/Himawari-8

Joji Ishizaka[1], Hiroshi Murakami[2], Kazunori Ogata[2,] Mitsuhiro Toratani[3]

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Japan Aerospace Exploration Agency (JAXA) launched Second-generation Global Imager (SGLI) as Global Change Observation Mission-Climate (GCOM-C) on December 23, 2017. This sensor can observe color of the earth together with temperature including ocean with 250m resolution with 1150 km cross track scan width, generally 2-day observation with 4 days cycle, with local descending time of 10:30am. The wavelength includes 380, 412, 443, 490, 530, 566, 672, 763, and 867nm. With the high resolution data, many of fine coastal events can be detected. After the 1-year verification phase which showed good performance of both optical and geophysical parameters, the version 1 global data is now opened from the download site G-Portal (https://gportal.jaxa.jp/gpr/). For limited area around Japan, near real time data with slightly better performance for chlorophyll-a is also easily obtained from JAXA Satellite Monitoring for Environmental Studies (JASMES) cite (https://www.eorc.jaxa.jp/cgi-bin/jasmes/sgli_nrt/index.cgi?lang=en).

Japan Metrological Agency (JMA) is operating Geostational Meteorological Satellite Himawari-8 with Advance Himawari Imager (AHI) from October 2014. AHI is the first color sensor for the Himawari series with 1 km resolution 470, and 640, 860 nm and 500 m of 510 nm with 2.5 min time resolution as well as 2 km resolution near infrared and infrared channels. Even this sensor was not design for ocean color with wider wavelength and lower S/N ratio, JAXA is providing hourly, daily and monthly chlorophyll-a data from Himawari-8 covering the full-disk area including southeastern Asia and Oceania area, with 1 km resolution around Japan and 5 km other than Japan from July 2015 (https://www.eorc.jaxa.jp/ptree/index.html). The data is limited quality for coastal area but fairly reasonable for open ocean.

Development and current status of the GOCI-II atmospheric correction algorithm

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We describe the current development status of the atmospheric correction (AC) algorithm for the second Geostationary Ocean Color Imager (GOCI-II), which will be following the GOCI mission. Atmospheric correction is a fundamental process in ocean color remote sensing that derives the water reflectance at the sea surface from the top-of-atmosphere. The traditional AC algorithms remove atmospheric path reflectance based on the radiative transfer theory by considering air molecules and aerosols. The GOCI-II AC algorithm is almost identical to the current GOCI method, then partially modified regarding the turbid water effect correction in near-infrared (NIR). While the current GOCI AC algorithm uses a 660 nm band to estimate water reflectances in NIR, the GOCI-II can additionally use 620 and 709 nm band, which makes it more advantageous for the estimation. The first candidate approach employs water reflectance spectral relationships between 709 nm and two NIR wavelengths as an extension of GOCI turbid water atmospheric correction, and the other candidate method uses a spectral relationship of IOPs between different wavelengths. The GOCI-II AC algorithm is preliminarily verified by synthetic data generated by radiative transfer simulations.

Improvement of atmospheric correction scheme for SGLI ocean color data

Mitsuhiro Toratani[1], Kota Katano[2], Masahiro Konno[2], Kazunori Ogata[3]

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The SGLI observation began in January 2018 and its Version1 dataset was released in December 2018. Currently, we are improving the processing algorithm for creating Version 2 data set. In this presentation, we will describe improvements to the atmospheric correction algorithm for SGLI ocean color toward the release of the Version2 data set.

The main improvements are the aerosol reflectance estimation in high-suspended matter concentration areas and the correction scheme for absorptive aerosol reflectance.

In high suspended matter concentration, the contribution of water at the near infrared region cannot be ignored. When the atmospheric correction was processed using Water-leaving reflectance at near infrared bands of AERONET-OC in Ariake Bay with relatively high suspended matter concentration, the accuracy of estimating aerosol reflectance, and hence the water-leaving reflectance at visible bands can be improved in consideration with water-leaving reflectance at the near-infrared region. The effect of improvement of aerosol reflectance scheme in turbid water is shown.

If absorptive aerosol exists, it is known to overestimate the aerosol reflectance on the shorter visible bands. In this study, the effect of absorptive aerosol was evaluated using radiative transfer simulation and the influence of absorptive aerosol generated by forest fire is evaluated. The effect of the absorbent aerosol correction method is shown.

Development of an Atmospheric Correction Method by Considering Inherent Optical Properties for a Specified Coastal Area

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GCOM-C/SGLI launched at the end of December 2017 by JAXA, has an excellent spatiotemporal resolution such as one-time observation every two or three days and the spatial resolution of 250m. Therefore, it is expected to monitor coastal areas where water environment change is significantly large, and the areas are comparatively small. However, the high accuracy of water quality estimation is exceedingly difficult because the light environment in coastal water changes complexly. In the traditional ocean color atmospheric correction algorithm, it is assumed that the water leaving reflectance in the near-infrared region is 0 and reflectance due to air in the visible bands is calculated after estimating the reflectance of atmospheric scattering. However, as in the coastal region, in the case of organic matter and inorganic matter increasing significantly, the water leaving reflectance in the near-infrared region increases and the assumption does not hold. Therefore, an aerosol reflectance is overestimated, and an error occurs in the estimation of the water leaving reflectance in the visible region band.

In order to resolve the problem, there is the iterative method of estimating aerosol reflectance while estimating water leaving reflectance in the near-infrared band using an in-water model, and it is widely used in almost ocean color sensors. However, typically, an in-water model in the iterative method is adequate for open ocean such as the case1 water; hence, an aerosol reflectance is still overestimated in a coastal area or other high turbidity water area such as the case2 water using this method.

In this study, we modified an in-water model of the iterative atmospheric correction algorithm which is adequate for case1 water to the in-water model considering SIOPs (Specific inherent optical properties) of coastal water as a target of Tokyo Bay where organic matter is dominant. Thereby, we constructed the atmospheric correction method which is the iterative calculation for estimation of aerosol reflectance from three estimated parameters of Chl-a(Chlorophyll-a), CDOM(Color dissolved organic matter) and NAP(Non-algal particles) using the Bio-Optical model created based on the measured SIOPs in Tokyo Bay. As a result of verifying of the constructed atmospheric correction method with the synchronous observation data with SGLI, the suggested method became possible to estimate the water leaving reflectance with higher accuracy compared to the method using in-water model adequate for case1 water.

Elucidating Back-Scattering Properties in Coastal Areas and Lakes by using Hydroscat-6p and Radiative Transfer Simulation

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In turbid waters, to figure out the accurate back-scattering properties are significantly difficult. In the measurement of b_b using Hydroscat (HOBI Labs) scattering sensors, the light attenuation effect from the sensor light source to the detector occurs because of the geometric problem of the device. Therefore, it is corrected by sigma correction based on the attenuation coefficient ($K_{bb} = a + 0.4b$). In the calculation of K_{bb}, usually, the a and b were measured by the Spectral Absorption and Attenuation Meter (AC-S-WETLabs) and then the sigma correction is applied to the uncorrected b_b, which was measured from the Hydroscat sensor. However, in turbid waters, these measurements are subject to uncertainties and require correction methods. In fact, depending on the correction methods, it gives a large effect on the results of the calculated remote sensing reflectance (R_{rs}) by radiative transfer simulation (de Carvalho, L. A. S., et al., (2015)).

In this study, the effect of the sigma correction in Hydroscat-6p measurement was figured out using radiative transfer simulations of Hydrolight in three types of water areas, Tokyo Bay, Lake Kasumigaura and the Gulf of Thailand. In addition, the light-scattering properties in the three water areas were elucidated and discussed their differences.

de Carvalho, L. A. S., Barbosa, C. C. F., de Moraes Novo, E. M. L., & de Moraes Rudorff, C. (2015). Implications of scatter corrections for absorption measurements on optical closure of Amazon floodplain lakes using the Spectral Absorption and Attenuation Meter (AC-S-WETLabs). *Remote Sensing of Environment*, *157*, 123-137.

Development of algorithm for detecting low-salinity plume in the East China Sea during the summer using GOCI

Young Baek Son[1], Joo-Hyung Ryu[2], Jong Kuk Choi[2], Kyeong-Hong Kim[3]

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The East China Sea (ECS) is a marginal sea that interacts with various surface water systems, including freshwater from the Changjiang River and the Taiwan Warm Current. The Changjiang River Discharge (DRD) disperse over a wide area in the Yellow Sea and ECS as a major freshwater source and forms the water type Changjiang Diluted Water (CDW) by mixing with ambient saline water. Particularly, in the summer, CDW extends eastward and disperses from the west of Jeju Island, Korea to the Korea/Tsushima Strait. This is due to the prevailing southerly wind with the increasing CRD. The extension of the CDW during the summer may be associated with increasing sea surface temperature under the formation of strong stratification.

To detect and trace offshore surface low-salinity water (LSW) in the ECS, a proxy was developed using surface water beam attenuation coefficient (c_p), and salinity matched with synchronous (Geostationary Ocean Color Imager) GOCI satellite data from 17-year summer cruises (1998, 2003-2018) using a two-step empirical approach. The hydrographic data collected from KIOST, NIFS, wave glider observations. For empirical approach, daily GOCI satellite images (~500 m, level 2) covering the ECS were obtained from Korean Ocean Satellite Center (KOSC). For making matching of spectral data in the temporal window, GOCI data were extracted for the location of the ECS sampling points when in situ and GOCI measurements were made with hourly window (8 times, 9h-16h local time). In order to obtain a reasonable matching data, the GOCI data must meet the following conditions: 1)>50% of the pixels are free of clouds within the 3 ×3 pixel, 2) to reduce the outliers the calculation used the filter mean value. First, a relationship between *in situ* salinity and c_p was obtained. Second, *in situ* c_p was matched with GOCI radiance ratios of all available blue-to-green wavelengths. Finally, satellite-derived surface salinity was determined directly by combining the two empirical relationships, providing a robust estimate over a range of salinities (22-34 psu). Our algorithm was then compared with other salinity algorithms based on CDOM. This significantly improves the limited spatial and temporal resolution of surface salinity distribution obtained by shipboard sampling. The resulting correlation is best explained as mixing between low-salinity plume waters and around normal saline waters. The empirical relationships were used to map satellite-derived salinity using the average of GOCI images during each summer cruise. As expected for summer, spatial patterns of LSW plumes with high c_p were connected to the mouth of the Changjiang River and extended to the east-northeast. Saline water with lower c_p was confined to the warm current and upper slope in the eastern part of the study area. This proxy approach can be applied throughout the region of shipboard sampling for more detailed coverage and analysis.

Attempts to improve the simulation of phytoplankton absorption spectra for various trophic statuses

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Ocean color researches facing a challenging issue to develop and train their models due to the limited resources of reliable field measurements that represent various trophic statuses. For instance, NASA provides about 5000 field measurements through NOMAD "NASA bio-Optical Marine Algorithm Dataset "in which measurements were conducted all over the world. The training of machine learning models require much more data. Consequently, simulated dataset can be considered the perfect solution to overcome the limitation of field measurements. The simulation of water-leaving reflectance spectra relies on three constituents, which are phytoplankton, non-algal particles (NAP)and colored dissolved organic matter (CDOM) along with the water itself. Our recent evaluation of Ciotti approach (Ciotti et al. 2002), one of the most common approach to simulate phytoplankton absorption, revealed that the approach suffers from two main limitations. Firstly, Ciotti's approach does not provide the dynamic variation of phytoplankton specific absorption spectrum to represent various species. Secondly, the magnitude of the simulated spectrum between 550 nm to 650 nm is very low comparing with reference datasets. The reference datasets to evaluate Ciotti's approach includes NOMAD dataset, local in-situ measurements and IOCCG Hydrolight simulated reflectance dataset. Our presentation will highlight these limitations along with our attempt to classify phytoplankton absorption spectral shapes using hierarchical clustering method. In addition, an assessment for the relationships between dominant phytoplankton size fraction (i.e., micro-, nano- and picophytoplankton) and water concentrations (e.g., Chlorophyll-a concentration) at each class will be also presented.

Development of bio-optical model considering the variation in dominant species of phytoplankton by hierarchical clustering

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The light environment in water changes by absorption and scattering of dissolved substances and suspended particles. The light absorption of phytoplankton is an important factor to determine the light environment in lakes and coastal areas which are eutrophic areas. Phytoplankton has characteristics of pigment composition according to the taxa. In coastal areas where dominant species change on a short-term scale, seawater always takes various colors depending on the community of phytoplankton (Kishino et al., 2001). In Tokyo Bay where one of the eutrophication semi-enclosed water area in Japan, the changes of dominant species occur several times for one year so that we need to classify the optical characteristics in each phytoplankton species. In this study, classified the specific light absorption coefficient of phytoplankton into the features of the spectral shape by hierarchical clustering, and confirmed the relationship in the dominant species. Next, we created the specific light absorption coefficient of each phytoplankton and applied it to the bio-optical model in Tokyo Bay. Finally, we clarified the effect of remote sensing reflectance (R_{rs}) on the calculation.

Field observations were conducted in Tokyo Bay. The light absorption coefficient of phytoplankton and Chlorophyll-a (Chl-a) concentration was measured by using the Quantitative Filter Technique (QFT) method and the fluorescence method and the specific light absorption coefficient (a^*_{ph}) was calculated from them.

Result of hierarchical clustering, the spectral shape of cluster 1 was expressed as Dinoflagellates (Micro-flagellates) and Cryptophytes (Cryptomonadaceae) for dominant species. The spectral shape of cluster 2 was expressed as Diatoms (Skeletonema costatum), and Chl-a 5.3 - 41.0 μg/l. The spectral shape of cluster 3 and cluster 4 were classified as Diatoms (Skeletonema costatum), and Chl-a (2.9 - 5.7 μg/l), and Diatoms (Thalassiosira sp. and Cyclotella sp.). Furthermore, R_{rs} was calculated by applying to the bio-optical model based on the classified a^*_{ph}. In-situ data of specific light absorption coefficient and slope coefficient for colored dissolved organic matter and detritus were used in the calculation (Salem, S., et al., (2017)). To confirm the effect of clustering, the backscattering coefficient, which was derived from in situ of R_{rs} and light absorption, was used and as a result, the calculation accuracy of R_{rs} had more improvement than using averaged a^*_{ph}.

Finally, the specific backscattering coefficients for phytoplankton and detritus ($b^*_{b,ph}$, $b^*_{b,d}$) into species of phytoplankton were classified and then applied it to the bio-optical model. As a result, the calculated Rrs varies widely compared to the in situ Rrs. It was found that the larger value of the standard deviation of the $b^*_{b,p}$, the more influence was exerted on the calculation of Rrs. In addition, $b^*_{b,d}$ had a greater effect on the calculation accuracy of Rrs. Therefore, an appropriate classification of b^*_b, especially detritus, is required.

Characterization of absorption and attenuation coefficients and their relationship with Chl-a in the southeastern Arabian Sea

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Diffuse attenuation $K_d(\lambda)$ and absorption $a(\lambda)$ coefficients are important parameters to characterize the optical variability in coastal marine environments. An attempt was made to describe and characterize the variation of diffuse attenuation and absorption coefficients along the southeastern Arabian Sea. The K_d and $a(\lambda)$ were calculated from the vertical profile measurements up to a depth of 50 m along the southeastern Arabian Sea from 8 to 12.3° N using Satlantic hyperspectral profiler. In the offshore waters (depth > 20m) the $K_d(\lambda)$ was less variable both in terms of the spectral shape and vertical profiles in the blue-green region than in the red region of the visible range. An empirical relationship was established between K_d and Chl-a for the study region (r=0.85, n=37, p<0.01). Comparison between QAA-modelled and MODIS Aqua-derived absorptions at different wavelengths showed significant correlation (r = 0.753, 0.836, 0.714, 0.709, 0.714 and − 0.347 at wavelengths 412, 443, 488, 531, 547 and 667 respectively) except for the red band. QAA estimated $a_{ph}(443)$ showed a significant correlation with the radiometer Chl-a concentration (r = 0.91, p<0.01). The comparison of QAA-derived a_{ph} at 443 nm with the in situ Chl-a concentration showed a good correlation (r=0.828; n = 30, p<0.01) suggesting that a_{ph} derived using semi-analytical QAA algorithm can be used to retrieve Chl-a concentration. The characterization of K_d and $a(\lambda)$ would enable better understanding of the optical variability in complex coastal waters of southeastern Arabian Sea. This study can be useful for fine tuning the existing algorithms or developing new regional optical algorithms for the coastal waters in tropical regions.

Keywords: Absorption, diffuse attenuation, southeastern Arabian Sea, QAA

Tracing sea surface warming and cooling in the East China Sea during summer

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The East China Sea (ECS) is a shallow marginal sea in the western Pacific Ocean and has a connection with strong human activity and economy in East Asia. Changes in oceanographic characteristics associated with global warming and, particularly, the Changjiang River Discharge (CRD), China are of great influence. However, such changes are poorly understood due to the sparse spatial and temporal observation data in this area. In order to understand the occurrence of the sea surface warming and cooling in the ECS during the summer season, we used the matrix analysis among sea surface temperature (SST), air temperature (AT) and heat flux. Hydrographic in-situ data (SST and surface salinity) collected from National Institute of Fisheries Science (NIFS) and KIOST. Daily and monthly SST used the MODIS- aqua data, and daily and monthly AT and heat flux used ECMWF (reanalysis data) from 2003 to 2019 (17 years).

SST in the ECS showed the lowest (average: 13.72°C) in March and the highest (average: 28.12°C) in August. AT was highly correlated SST and showed a similar seasonal change. In August, SST was higher than AT and continuously higher than AT until winter. To determine the change of the summer SST, we considered the sea surface warming events that SST anomaly is higher than 1°C, and used SST anomaly value in August to classify the positive and negative periods. Sea surface warming occurred in 2004, 2006, 2013 and 2016. Especially in August 2016, SST anomaly was more than 1.5°C and the distribution of temperature showed very significant warming in the ECS. The variation of SST was well correlated with the change of AT (R value: 0.65). Net heat flux was increased in the ECS where the difference between SST and AT was large.

Spatial variations between the two periods indicated that SST are relatively larger variations in the northern parts, which was controlled by the atmospheric forcing. The shallower depths of the ECS toward the north was intensified with the change of SST due to the interaction of the atmosphere. In the southern parts, SST was influenced by the extension of the Kuroshio Warm Current, so the change of SST in the southern parts of the ECS was more stable than the northern parts.

SST and AT were highly correlated, but there were some years that did not match this trend. SST in August 2010, 2012 and 2019 was decreased by 0.5°C compared to AT. It is considered to be caused mixing of surface and bottom layer due to well-mixing by typhoons penetrating. The decrease of SST may continue or be strengthened for a long time due to continuous upwelling caused by inertial motion. In August 2015, AT was relatively lower than SST (>0.5°C). It might be due to weakening of the East Asian Summer Monsoon that affecting AT of East Asia through expansion and reduction of Okhotsk high. In August 2016, SST and AT were the highest during the study period and SST was higher than AT (>1°C). This result was related that large amount of freshwater discharged from the Changjiang River, China. The behavior of the Changjiang River plume contributed to sea surface warming over the northern ECS. It caused the salinity-induced density stratification, which enhanced the barrier layer between mixed and isothermal layer depth. It made the sea surface warming due to the lack of vertical heat change.

Spatial variability of fishing grounds over oceanic front changes detected by multiple satellite measurements in the East (Japan) Sea

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In the East (Japan) Sea, the ocean fronts resulting from coastal upwelling and eddies affect the formation of fishing grounds by creating an environment with abundant food resources. The aim of this study was to examine the relationship between fishing activities and the locations of these ocean fronts. To do this, Day/Night Band (DNB) images were used, and ocean fronts were detected based on satellite ocean color data. It was found that the illuminated pixels on the DNB images were related to the number of sailed out boats (coefficient of determination, R^2 = 0.55) and so may represent the number of fishing activities.

Consequently, a new index was developed to assess the spatial correlation between the locations of fishing activities and ocean fronts, referred to as the “DNB score,” which combined the scientific method of determining the locations of regional ocean fronts with the social method of observing the locations of fishing activities based on fishermen’s experiences. The DNB score was approximately 21% for the coastal upwelling front and 44% for the eddy front. Since most boats with lights in the East Sea are known to be fishing for *Todarodes pacificus*, the relationship between the DNB score and the catch of *T. pacificus* was also examined. This showed that the DNB score reflected the temporal catch variability and the catch per unit effort of *T. pacificus*, suggesting that it could be used as an index to evaluate the location of fishing grounds in association with fishing activities.

Estimation of hourly sea surface salinity in the East China Sea using Geostationary Ocean Color Imager measurements

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Sea surface salinity (SSS) is an important tracer for monitoring the Changjiang Diluted Water (CDW) extension into Korean coastal regions; however, observing the SSS distribution in near real time is a difficult task. Even though the Korean National Fisheries and Research Development Institute has been conducting ocean observations in the East China Sea (ECS), these surveys are insufficient in specific areas leading to limitations when investigating the SSS distribution. Therefore, this study aims to develop a multilayer perceptron neural network (MPNN) algorithm to estimate the SSS based on Geostationary Ocean Color Imager (GOCI) and sea surface temperature (SST) data. As in previous similar studies, various combinations of input measurements were used to train the MPNN model. A combination with 3 to 6 GOCI remote sensing reflectance (Rrs) bands, SST, and coordinate information (longitude and latitude) was found to work best for estimating the SSS in this study. According to model validations with the Soil Moisture Active Passive (SMAP) and Ieodo Ocean Research Station SSS measurements, the values of the coefficient of determination (R2) were 0.81 and 0.92 and the root mean square errors (RMSEs) were 1.30 psu and 0.30 psu, respectively. Maps of R2 and RMSE between the SMAP and GOCI SSS were examined to understand the spatial differences in the MPNN model performances. In addition, a sensitivity analysis revealed the importance of SST and the red-wavelength spectrum signal for estimating the SSS. Finally, hourly estimated SSS images were used to illustrate the hourly CDW distribution. With the model developed in this study, the near real-time SSS distribution in the ECS can be monitored using GOCI and SST data.

Imprints of Indian Ocean Dipole on surface circulation and Chlorophyll and Oxygen distributions of the Arabian Sea- A remote sensing perspective

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Arabian Sea receives much attention as it is a unique region, with seasonally reversing monsoons and the associated marine environmental variability. The present study analyses the inter-annual variability of surface circulation of Arabian Sea, especially the changes associated with the Indian Ocean Dipole events, combining remote sensing and satellite observations. High resolution Eulerian mean velocity field had been derived by combining the available satellite tracked surface drifter data with satellite altimetry and ocean surface winds. The drifter data used in this study includes Argos and surface drifter data from Global Drifter Program. Maps of Sea Level Anomaly (MSLA) weekly files with a resolution of 1/3° in both Latitude and Longitude for the period 1993-2012 had been used. The weekly ocean surface mean wind fields derived from the scatterometers onboard ERS, Quikscat and ASCAT had been employed to estimate the wind driven component. The Chlorophyll *a* and Oxygen data were obtained from CMEMS GLOBAL_REANALYSIS_BIO_001_029.

The major features observed in the mean current field are the western boundary Somali Current, weak westward North Equatorial Current, weak West Indian Coastal Current and significant eastward flows near the equator. Somali Current is the strongest current in the Arabian Sea and its mean speed even reaches above 1.8 m/s July. Besides strong currents, the Arabian Sea exhibits strong mesoscale eddy activity in the western side. Significant changes were found in the flow pattern during IOD events. Both positive and negative IOD conditions differently influence the circulation of Arabian Sea, specifically the equatorial currents, western and eastern boundary flow pattern. Significant inter-annual changes were observed in the distribution of dissolved oxygen and Chlorophyll during Indian Ocean dipole events. Mostly, the advective transport determines the oxygen distribution whereas, the convective processes controls the Chlorophyll distribution.

The decadal trend and seasonal patterns of the surface chlorophyll-a in 12 Large Marine Ecosystems in the North Pacific

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We investigate and compare the decadal and seasonal variability of the surface chlorophyll-a in 12 Large Marine Ecosystems (LMEs) in the North Pacific as a part of the North Pacific Ecosystem Status Report being prepared by PICES (North Pacific Marine Science Organization). For this analysis, we used MODIS (Moderate Resolution Imaging Spectroradiometer) Aqua data for the period of 2003-2018. The North Pacific as a whole has experienced an alternation of cool-warm-cool (or warm-cool-warm depending on west/east point of view) phases during this period. On a basin scale, the surface chlorophyll-a has undulated in an anomaly pattern out of phase with the PDO (Pacific decadal oscillation). The signal was particularly strong in the eastern North Pacific coastal ecosystems, e.g., the marine heat wave in 2014-2015. On a regional level, the 12 LMEs have shown a spectrum of different responses in terms of direction and magnitude. Here, we discuss the different patterns and possible causes of the variability in the surface chlorophyll-a in the 12 LMEs in the North Pacific.

Variability of Satellite Chlorophyll-a over the Spring-Neap Tidal Cycle in the Turbid Ariake Bay, Japan

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Variability of satellite chlorophyll-a (Chl-a) over the course of the spring-neap tidal cycle in the whole Ariake Bay and Yatsushiro Bay was investigated with a 16-year (2002-2017) of locally tuned MODerate resolution Imaging Spectroradiometer (MODIS)-Aqua datasets. The influences of total suspended sediment (TSM) and river discharge on Chl-a were quantitatively analyzed. Annual and seasonal climatology and individual spring-neap tidal cycle of MODIS Chl-a and TSM at the four tidal stages, namely, spring to neap (SN), neap (N), neap to spring (NS) and spring (S) tides, were produced. Our results suggest that Chl-a peaks generally occur during the N tide and also occur during the transition period of N to S tide, whereas TSM peaks generally occur during the S tide. Chl-a and TSM were negatively correlated over the spring-neap tidal cycle as Chl-a mostly increased in N when TSM was low and decreased in S when TSM was high. These results are consistent with previous field studies of local and short time series data which have indicated that the phytoplankton growth in Ariake Bay is light-limited during the turbid S tide. This confirmed that tidal resuspension is an important factor for the variation in Chl-a over the tidal cycle. However, some Chl-a peaks were observed in SN tide following some peaks of high river discharge mostly in summer. In general, river discharge was strongly and positively correlated with Chl-a for both the seasonal climatology and individual spring-neap tidal cycle data. There was no correlation between river discharge and TSM, and the high Chl-a/TSM ratios (>1:600) which indicated that phytoplankton was dominant in TSM mostly occurred in summer when river discharge was the highest. This suggested that river discharge is another important factor for the Chl-a variation over the spring-neap tidal cycle, specifically in summer. This is the first study to examine satellite Chl-a with TSM over the spring-neap tidal cycle, and the results indicated that locally-tuned ocean color data is useful to understand the dynamic of phytoplankton in the tidally dominated bay.

Keywords: Ariake Bay, MODIS, variability, chlorophyll-a, spring-neap tides, total suspended sediment, river discharge.

Seasonal variability of green *Noctiluca* in the upper Gulf of Thailand

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Green *Noctiluca scintillans*, the peculiar single cellular heterotrophic organism containing photosynthetic algae called *Pedinomonas noctilucae*, frequently causes harmful algal bloom (HAB) in the upper Gulf of Thailand (uGoT). The bloom is often reported with fish kills due to sudden oxygen reduction, and tourism disruption due to the dirty seawater and foul odor. Although it is expected that the bloom is related to anthropogenic impacts such as eutrophication and climate change, little is known why and how the bloom occurs. During 2017 – 2019, we conducted the ship observations to obtain the bio-optical data of green *Noctiluca* blooms and other HABs, such as *Ceratium furca* and diatoms. The optical spectra showed the distinct features of green Noctiluca blooms due to the specific pigment composition in the cell. In this study, we developed an empirical algorithm for identifying green *Noctiluca* blooms based on the *in situ* reflectance spectra and applied the algorithm into MODIS data to investigate seasonal patterns of green *Noctiluca* distribution in the uGoT. The investigation result of the seasonal variability of green *Noctiluca* blooms will be shown and discussed under the influences of two monsoons that impacts the chl-a variations in the uGoT.

The Distribution of Chlorophyll-a Concentration and Fish Catch during the Indian Ocean Dipole 2019 in the Eastern Indian Ocean off Palabuhanratu Bay

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In the past 10 years have been occurred 3 times the climate variability Indian Ocean Dipole (IOD) positive phase and the last on 2019 this year. We collected ocean color data and conducted field observation to analyze the impact of the positive IOD phase on the distribution of Chlorophyll-a (Chl-a) concentrations, vertical profiles of temperature and salinity in the East Indian Ocean off Palabuhanratu Bay. We also observed the fish catches landing at the fishing ports. The vertical profile of temperature and salinity show that the upwelling process during IOD (+) very strong. The average of Chl-a concentrations both of from ocean color and field observation were 5 mg/m3, was higher than normal condition. The total fish catch landing at the fishing port more than 3 times than normal condition and many juveniles were caught. These studies shows that the positive phase of the IOD significantly influences the oceanographic and fishery conditions in the Palabuhanratu Bay and surrounding.

Dynamic Forcing for the Chlorophyll Blooms off Northern Borneo

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A remote-sensing analysis by *Sun* (2017) shows that winter phytoplankton blooms off northwest Borneo (Kalimantan Island) are caused by nutrient inputs from river discharge and the bloom intensity is interannually anti-correlated with the ENSO. Strong (weak) chlorophyll blooms tend to occur in La Nina (El Nino) years. The finding seems to contradict with the earlier studies by *Isoguchi et al.* (2005) and *Yan et al.* (2015) which argue coastal upwelling contributes to the phytoplankton blooms and strong blooms occur in El Nino years. Here we show that the shelf water off Northern Borneo has two dynamic regimes: the broad area off the Sarawak coast is dominated by the riverine influence, and the northern tip off Sabah is dominated by wind-driven coastal upwelling.

Seasonal and Interannual Variations of Sea Surface Chlorophyll-a in the Southern Makassar Strait Revelaed by MODIS

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Seasonal and interannual variations of surface chlorophyll-a (chl-a) in the southern Makassar Strait were investigated using long-term MODIS data. Particular emphasis was put on the influences of the coupled ocean-atmospheric modes in the tropical Indo-Pacific region, namely the Indian Ocean Dipole (IOD) and the El Niño-Southern Oscillation (ENSO). Unique features of anomalously cold sea surface temperature (SST) were observed off the southern tip of Sulawesi Island during the southeast monsoon season (June-July-August/JJA). This cold SST anomaly was induced by strong southeasterly winds leading to offshore Ekman transport. As a result, anomalously high surface chl-a concentration was observed co-located with cold SST anomaly. However, the cold SST anomaly was not observed along the eastern coast of South Sulawesi. Instead, a relatively warm SST anomaly appears in this area. Note that north-south elongated mountain chains in the Sulawesi Island block the southeasterly winds and thus weakened the offshore Ekman transport. As a result, high surface chl-a was not observed along the eastern coast of Sulawesi. During the positive IOD and/or El Niño years, extremely high surface chl-a concentrations were observed in the southern Makassar Strait. It was found that the southeasterly winds were strengthened during positive IOD and/or El Niño years resulted in unusually strong upwelling leading to surface chl-a bloom in the southern Makassar Strait. Note that the surface chl-a bloom was extended further offshore and lasting longer until October.

Study of Internal solitary waves and chlorophyll-a distribution patterns in Flores Sea, Indonesia using satellite data

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Indonesian seas play an important role in the global ocean circulation with the Indonesian Throughflow (ITF) due to the inter-ocean flow from the Pacific Ocean to the Indian Ocean. Flores Sea is one of the substantial part of the ITF in the eastern pathways. Satellite data approach based on ocean color, optical and synthetic aperture radar (SAR) is employed to study the internal solitary waves (ISWs) and chlorophyll-a distribution patterns in the Flores Sea, Indonesia, where the surface manifestations were found to be associated with the chlorophyll-a distribution patterns. The ISWs have been detected in satellite images in Flores Sea. Evidence of the consistency of ISW patterns were detected in SAR, optical and chlorophyll-a. The chlorophyll-a concentration from MODIS-Aqua clearly show the packet manifestation of ISW. The chlorophyll concentration is enhanced and reduced along the propagation direction of the ISW-crests. The remote sensing reflectance, Rrs_555 (green light), from MODIS-Aqua have a profile that is consistent with the crest of the ISW profile on the MODIS surface reflectance. Sentinel-1A SAR image (2 days before the MODIS-Aqua image) also confirmed the same ISW patterns in the study area.

Assessment of phytoplankton abundance using remote sensing reflectance data and Chlorophyll-a data derived using Aqua-Modis satellite to monitor massive fish kills in the Jakarta Bay

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The Jakarta Bay has been experienced 3 decades severe eutrophication due to high nutrient inputs originated from various activities of nearly 30 million residents living in the Jakarta mega-metropolitan city and its hinterland cities called the Jabodetabek areas (Jakarta-Bogor-Depok-Tangerang-Bekasi). Those nutrients enter the bay through 13 river and channels caused frequent high phytoplankton blooms and triggered massive fish kills. This study aims to develop an empirical model to estimate phytoplankton abundance (cell/m^3) using remote sensing reflectance data (Rrs) and Chlorophyll-a concentration (Chl-a) drived from Aqua-MODIS satellite that obtained from Giovanni NASA's web, and field phytoplankton sampling data of 2008-2011, 2013 and 2015. The empirical model shows that phytoplankton abundance correlated strongly with the average ratio of Rrs all Green to Rrs all Red bands (R^2=0.74) as well as with Chl-a (R^2= 0.89). This empirical model was used to map phytoplankton abundance and then was used to explain massive fish kills in the Jakarta Bay. Phytoplankton blooms (HAB), which dominated by diatoms during the two big fish kill events of 2004 and 2015 have a very high abundance of 2 million cell/l and 3 million cell/L, respectively. The massive fish kills triggered by drastically dissolved oxygen (DO) depletion (<2 mg/L) or even to hypoxic (0 mg/L), which coincidently followed by a weak water masses exchange after HAB. This finding shows that the empirical model developed using Rrs data of Aqua-MODIS satellite can be directly applied to estimate phytoplankton abundance and to describe eutrophication dynamics, and its relation to massive fish kills of this bay. Nevertheless, this study still requires a lot of validation.

Keywords: Phytoplankton abundance, Rrs, Aqua-Modis, Fish kills, Jakarta Bay

The distinction of green and golden tides using reflectivity characteristics

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The occurrence of macroalgae blooms (MABs) has been reported since the early 20th century (Cotton, 1910). Since the 1970s, MABs have expanded due to coastal eutrophication as the world has become more industrialized (Smetacek and Zingone, 2013). The main genera responsible for MABs are *Ulva* and *Sargassum*, which are named 'green tide' and 'golden tide', respectively. The Yellow Sea (YS) and East China Sea (ECS) have the world's largest supply of floating algae. The green and golden tides appear mainly in the YS and ECS, respectively, but become entangled as they drift. The floating algae obstructs navigation and is a huge socioeconomic problem in the vicinity of coastal areas. To manage these floating algae more systematically, a method of distinguishing between the green and golden tides is required.

In this study, the reflectivity characteristics of green and golden tides appearing in the YS and ECS were investigated, based on which a classification method was proposed and applied to multi-satellite sensors. First, we measured the reflectance of *Ulva prolifer*a and *Sargassum horneri* using TriOS-RAMSES (TriOS), which are the major causative species of green and golden tides in the YS and ECS, respectively. To investigate the reflectivity of *U. prolifera* and *S. horneri*, algae samples were collected from Muan and Shinan, Jellanam-do Korea, respectively. Under visible light, the reflectance of *U. prolifera* increased at 555 nm, and that of *S. horneri* increased at 602 and 646 nm and decreased at 632 nm. To distinguish the two algae, we proposed a method based on the red and green reflectance slope (slope of red-green; SRG). *U. prolifera* exhibited a SRG that was always negative, whereas that of *S. horneri* was always positive. It used the slope of red and green to distinguish the two algae tides that the threshold of the green tide was negative value and the threshold of the golden tide was positive value. We compared the reflectance characteristics of floating algae according to various satellite sensors (Terra/MODIS, COMS/GOCI, Sentinel-3/OLCI, Landsat7/ETM+, Landsat8/OLI, and Sentinel-2/MSI), when the SRG was applied to the difference in reflectance values between floating algae and nearby water detected in satellite imagery, the green tide was always negative value, and the golden tide was always positive value. This method had been applied equally successfully in *in-situ* and satellite data.

To improve the ability to distinguish two or more floating algae, the sensor should have a band specialized for floating algae detection, or a hyperspectral sensor capable of high spatial resolution. However, this proxy approach will map the massive floating algal blooms based on multi-satellite data on regional levels. Classification and detection of floating algae using multi-satellite sensors and the satellite monitoring using SRG method can reduce the associated management cost and time.

Detection of seagrass beds by Google Earth Engine in western Nanao Bay

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Western Nanao Bay is an enclosed bay, located on the east side of Noto Peninsula, Ishikawa Prefecture. Due to its topographical features that are surrounded by the land, water remains relatively calm throughout the year and it forms a suitable condition for seagrass habitat. Seagrasses provide valuable ecosystem services such as maintaining marine biodiversity, regulating quality of coastal water and protection of the coast line. A large-scale die-off of seagrass from late summer to early autumn has been reported in western Nanao bay in recent years. Here we demonstrate use of Google Earth Engine, a cloud-based platform for planetary-scale environmental data analysis, to monitor spatio-temporal variability of seagrass beds in western Nanao bay.

Imprint of climate variability on Indo-Pacific ocean surface biology

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Bounded by densely populated countries and located between the Pacific and Indian Oceans, the southeast Asian marine ecosystems are greatly impacted by both anthropogenic activities and climate variations of ENSO and IOD. Assessing the change in the state of surface ocean biology is one of the important indicators of climate change impacts, especially that represented by phytoplankton because they are important agents not only as a base of food web but also in regulating ocean biogeochemical processes. Using two-decade ocean color data of phytoplankton biomass, we will present climate change fingerprint on phytoplankton biomass in the southeast Asian marine environments.

Physiological flexibility of phytoplankton impacts modeled chlorophyll and primary production across the North Pacific

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Phytoplankton of various taxa are known to adjust their elemental compositions and pigment ratios in response to the changing light and nutrient conditions in the near-surface ocean. Although a wide variety of physiological photo-acclimation models have been developed and tested against laboratory results, their application and testing against oceanic observations remains limited. Hence the biogeochemical implications of photo-acclimation in combination with ocean circulation have yet to be fully explored. We compare modeled biomass and production from a recently developed phytoplankton model (FlexPFT), which incorporates photo-acclimation and variable C:N:chl ratios, to that obtained with an inflexible control model, which is a typical NPZD-type model based on Monod kinetics for growth assuming fixed C:N:chl ratios. We conduct simulations using a 3-D physical model (OFES) coupled to these two biological models (FlexPFT and NPZD, respectively), to evaluate each model's performance. We compare model results to observed seasonal cycles of primary production, chlorophyll, and nutrients in the surface layer at two contrasting time-series sites, stn. K2 (subarctic gyre) and stn. S1 (subtropical gyre) in the western North Pacific and investigate the seasonal and spatial patterns of primary productivity, chlorophyll, and nutrients in the surface layer across the North Pacific. These two models produce different vertical distributions and seasonal cycles of primary production at the two observation stations. Compared to the NPZD model, the FlexPFT has more intense peak production, which occurs closer to the surface at both stations, and a more even seasonality with a more intense sub-surface chlorophyll maximum at stn. S1. The models also produce different patterns of primary production at the basin scale, in particular for the Kuroshio, Kuroshio Extension, and California Coastal regions.

Poster Session

Spatiotemporal variability of chlorophyll-a in the Andaman Sea (1998-2018)

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The Andaman Sea is marginal sea of the eastern Indian Ocean bordering the Andaman Island of India, southern coast of Myanmar, west coast of Thailand, and northern coast of Indonesia. Here, I investigated the spatiotemporal variability of the chlorophyll-a concentration in the Andaman Sea for 1998 to 2018 using merged SeaWiFS, MODIS-Aqua, MERIS, and VIIRS version 4 remotely sensed data provided from Ocean Color Climate Change Initiative (www.oceancolour.org). During the last two decades, the chlorophyll-a was consistently high throughout 2002 to 2011 in the northern part of Andaman Sea and low since 2012. Although the Andaman Sea ecosystem has experienced abrupt changes in the chlorophyll-a, it has received little attention to date. Thus, the aim of this study is to better understand major factors controlling the variability of chlorophyll-a in the northern region of Andaman Sea and to discuss the possible of cause of high chlorophyll-a during 2002 to 2011.

Effect of high atmospheric Nitrogen Dioxide (NO_2) concentration on GOCI ocean color products

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This study investigates the effect of atmospheric NO_2 on Geostationary Ocean Color Imager (GOCI) ocean color products over the seas around Korean Peninsula. For ocean color remote sensing, absorption and scattering contributions by ocean components (phytoplankton, Colored Dissolved Organic Matter (CDOM), Non-Algal Particles (NAP), etc.) tend to be much weaker than those from the atmosphere (e.g., gas and aerosol). Thus, the contribution from atmospheric components has to be properly removed to retrieve more accurate ocean color products. Whereas the current GOCI atmospheric correction considers absorption by ozone and water vapor, the absorption effect by NO_2 is not applied. Recently, some previous studies have shown that high NO_2 conditions can cause serious errors in the Top of Atmosphere (TOA) reflectance especially in the blue channel. We are developing NO_2 absorption correction technique in GOCI ocean color algorithm.

Currently, we examine whether there is any notable spatial pattern in GOCI remote sensing reflectances (R_{rs}) and Chlorophyll-a (Chl-a) for high NO_2 absorption cases using Ozone Monitoring Instrument (OMI) NO_2 data. 6S radiative transfer model was used to calculate transmittance with and without NO2 absorption in the high NO_2 conditions.

The GOCI-II will be on loaded on Geo-Kompsat-2B(GK-2B) together with Geostationary Environmental Monitoring Satellite (GEMS). Through the combination with GEMS data, the GOCI-II is expected to the first ocean color sensor which performs NO_2 absorption correction in real-time.

Chlorophyll-a variability in the Gulf of Thailand during El Niño event from MODIS data

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The Gulf of Thailand (GoT) located in tropical area, is a semi-enclosed shallow sea. This area bordered by Vietnam, Cambodia, Thailand, and Malaysia. This area is important for fisheries production. For seasonal variability, GoT is influenced by the monsoon system; wet and dry season in the southwest (May-September) and northeast monsoon (November-January), respectively. For inter-annual variability GoT is affected by El Niño Southern Oscillation (ENSO) as results of dried and wetter weather during El Niño and La Niña, respectively. Due to ENSO, wind, precipitation, freshwater discharge, and nutrient loading may be changed, and this variation can influence to the marine ecosystem in this area. The objective of this study is to investigate the impacts of ENSO to chlorophyll-a (chl-a) concentration in the GoT by using satellite data. Seventeen years data (2002-2018) of surface chl-a from Moderate Resolution Imaging Spectroradiometer (MODIS) level 3 were used to investigate. The results were compared with environmental parameters including Sea Surface Temperature (SST), river discharge and wind magnitude.

The results from seasonal climatology illustrate low and high chl-a occurred in non-monsoon (February-April) and northeast monsoon, respectively. It is expected that the chl-a concentration is responding to water column conditions which stratified in the non-monsoon and well mixed in the northeast monsoon corresponding to the highest and lowest SST, respectively. High chl-a was found along the coast, especially at the northern coast during southwest monsoon probably due to strong wind made water mixing in that area. High chl-a was also found near cape CaMau during northeast monsoon probably due to wind induced surface current flew into GoT from the South China Sea, which might bring nutrients from Mekong river to GoT mouth.

For the El Niño periods, chl-a concentration in GoT was lower by negatively correlated with SST anomaly. It is expected that enhancement of water stratification result to low chl-a corresponding to the increase of SST. The chl-a concentration was lower in most of the gulf, especially in the western and upper GoT from middle of southwest monsoon and became lowest in November and December. Chl-a concentration in the coastal area was more related to pattern of river discharge anomaly.

Inherent and apparent optical properties in the Seto-Inland Sea in summer

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Three field observations during summer 2010 were carried out to measure the inherent and apparent optical properties of the western Seto-Inland Sea, Japan. The first observation was conducted in July 2010 when diatoms flourished, the second was in August 2010 when dinoflagellate *Karenia mikimotoi* density was high in the Beppu Bay. The third observation was carried out in September 2010 when there was no phytoplankton bloom.

Phytoplankton chlorophyll-a concentrations (Chl-*a*, mg m^{-3}) was highly correlated with phytoplankton absorption coefficient (a_{ph}, m^{-1}) ($r = 0.97$). Gelbtoff absorption coefficient (a_g, m^{-1}) showed strong correlation with surface salinity ($r = 0.88$). The highest Chl-*a* measured during diatom bloom and during *K. mikimotoi* high density was 14.3 mg m^{-3} and 5 mg m^{-3}, respectively. In the blue spectral domain, a_{ph} in diatom bloom waters was about three times higher than that in waters with high density of *K. mikimotoi*.

Hyperspectral remote sensing reflectance (Rrs, sr^{-1}) measured during diatom bloom and *K. mikimotoi* high density showed different spectral shapes, particularly in the slope of Rrs between the blue (440 nm) and the green (550 nm) bands. The blue-green spectral slopes during diatom bloom were much steeper than that during high density of *K. mikimotoi*. More in situ Rrs measurements are required to generate hyperspectral libraries of phytoplankton groups and other types of waters in the Seto-Inland Sea.

Persistent Cloud Cover Curtails the Spring Phytoplankton Peak in the Toyama Bay

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Toyama Bay, on the Japan Sea, is a very dynamic and steep bay, generally with depths greater than 200 m confined to the narrow shelf, and with many rivers flowing into the bay. The Jintsu River is one of the major rivers in terms of discharge amount averaging to > 500 m^{-3} s^{-1} during the peak months. Previous studies on phytoplankton seasonality in the Toyama Bay reported the typical annual cycle of temperate regions dominated by spring and autumn blooms associated with increasing solar radiation in spring and deepening vertical mixing in autumn. In the shelf regions where the influence of river discharge is high, the seasonality of phytoplankton is reported to be dominated by a long summer peak which is significantly correlated with river discharge. Yet, the river discharge is equally high or even higher in spring during snow melting. Nevertheless, no significant correlation between chlorophyll-a peak and river discharge has been observed during springtime.

In this study, we reevaluate the influence of river discharge on phytoplankton seasonal cycle. The understanding of seasonal and spatial variations in chlorophyll-a is often limited by data availability and satellite observations in the Toyama Bay are precluded by persistent cloud cover, especially during winter months. Here, we hypothesize that persistent cloud cover observed in Toyama Bay contributes to shifting the spring phytoplankton peak into summer peak when cloudy conditions are significantly reduced. As a support to the hypothesis, a significant correlation between the data availability (count of cloud free days) and chlorophyll-a peak are observed within the region previously reported as having a summer peak type. This presentation will discuss the preliminary analysis of the relationship between cloud cover and chlorophyll-a peak in the Toyama Bay.

Analysis of ocean optical characteristics in the coastal waters of Yeosu in 2017

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Red tide is a marine pollution phenomenon in which algae inhabiting the ocean multiplies in large amounts at a time, discoloring the color of seawater and affecting marine life. It occurs annually over the coastal area, causing direct damage to fishermen. Research of red tide using remote sensing has been studied in various methods (Noh et al., 2018; Choi et al., 2014; Son et al., 2012; Ahn and Shanmugam, 2006; Ahn et al., 2006). However, most of the research focused on insitu data and satellite data analysis, and mainly relied on apparent optical properties (AOPs). The optical properties of seawater are due to complex phenomenon of Inherent optical properties (IOPs) and AOPs caused by seawater particles. Therefore, it is important to understand the optical characteristics of seawater. South Sea of Korea is complex coastal area, frequent red tide in summer. The purpose of this study is to investigate general ocean optical characteristics of Yeosu coast of South Sea during the summer in 2017 without red tide, as a radiance model. IOPs and AOPs (remote sensing reflectance, absorption coefficient, downwelling irradiance, water leaving radiance) will be analyzed. By comparing these ocean optical variables, we will analyze which variables affect red tide in terms of ocean optics. We will also compare the model data with the ship observation data using Water Colour Simulator (WASI) software developed by Peter Gege. Based on this, we will understand absorption characteristics with red tide from data in 2018.

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Development of Level-2 Data Processing Software for GOCI-II

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Geostationary Ocean Color Imager II (GOCI-II) ground system is being developed for satellite data reception, processing and distribution, following schedule of GOCI-II launch in March 2020 and six-month In-Orbit Test (IOT) after the launch. Korea Ocean Satellite Center (KOSC) conducted several researches for developing 26 level-2 ocean color algorithms specific to GOCI-II and also implemented the Level-2 Generator (L2Gen), GOCI-II level-2 data processing software. L2Gen is based on the GOCI Data Processing Framework (GOPF) and the Ocean Color application Auto-Acceleration framework (OCAccel) developed by KOSC for efficient data processing. GOPF is available in Python and C++ and provides standardized input/output of GOCI-II and ancillary data to generate the NetCDF file that can be handled by the ESA's Sentinel Application Platform (SNAP). In addition, it is possible to modify the defined variables (*e.g.* coefficients and thresholds) in each algorithm's configuration file so that the algorithms can be flexibly utilized without the source code modification and rebuilding. OCAccel is available in C++ and automatically translate the sequential source code into the parallelized source code to facilitate General-Purpose Graphical Processing Unit (GPGPU) programming. This makes it easy for users to take advantage of the powerful computing resources of GPU and it is possible to process large-scale data at very high speed. Moreover, L2gen supports slotted processing for GOCI-II data and the NetCDF files are generated in slots. Thus, we introduced a job scheduler for the High Performance Computing (HPC) system so that the algorithms can be distributed at the same time. In this study, we performed the experiment that shows performance of L2gen in the KOSC's HPC system and simulation data using GOCI data were used as input data. As a result, it was confirmed that the level-2 slot data was processed and distributed to users within 10 minutes after receiving the slot data from the GOCI-II payload. Lastly, L2gen will be offered through SNAP for users, as well as KOSC's HPC system. L2gen software will be distributed with GOCI-II Level 2 products.

Water Temperature Prediction and Gyroscope Signal Denoising using Deep Learning Technology

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Section 1: Gyroscope signal denoising technology using MLP

As from January 1, 2020, the International Maritime Organization (IMO) will enforce strong regulations limiting sulfur content of ship fuel oil from 3.5% to 0.5% to reduce air pollutants. It is important to limit sulfur content of ship fuel oil to reduce air pollutants, but it is also important to reduce unnecessary energy waste during ship operation. In order to do this, the ship needs to maintain the designated route correctly. To maintain the sea route, a ship used autopilot system composed of controller such as PD type, Fuzzy PID type, etc. These type controllers have excellent performance on the assumption that there is no noise. However, in a real environment, measurement noise caused from gyroscope is applied to autopilot system, which degrades the performance of controller. In order to solve this problem, Kalman Filter, which is widely used for state estimation, is applied, but this also cannot completely eliminate noise. In this study, therefore, the denoising method to reduce effect of noise is proposed by combining Kalman Filter and Multi-Layer Perceptron (MLP) which is a kind of artificial neural network. Since motions of a ship are divided into the forward direction and the rotation motions, Kalman Filter is applied in case of forward direction motion and MLP is applied in case of rotation motion.

Section 2: Water Temperature Prediction using LSTM

Recently, due to global warming, abnormal high water temperature phenomenon occurs frequently on the coast of the Korean peninsula, which causes huge damage to marine fisheries every year. It also causes human injuries form Vibrio bacteria which breed in fish and shellfish that died at high water temperatures. So to alleviate the damage caused by abnormal high water temperature, it is necessary to respond as quickly as possible or make advance forecasts. However, unfortunately it is impossible to monitor a wide range of oceans at the same time, the damage has been increased by the late response every time. In order to solve these problems, in this study, water temperature prediction model based on LSTM is proposed to predict abnormal high water temperature phenomenon in advance. The used data to predict water temperature is sea surface temperature (SST) data providing at the European Center for Medium-Range Weather Forecasts (ECMWF). About 10 years of SST data is used to training LSTM model and trained LSTM model is used to predict future water temperature to prevent damage caused by abnormal high water temperature.

Look Up Table Development of Simulated In-Situ Bio-optical Dataset for Satellite Data Product Classification

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Global satellite ocean color product provides the scientific community better understanding quality monitoring. One of satellite derivation product is remote sensing reflectance need to be altered correctly regarding its optical properties. The alteration of remote sensing reflectance is water classification which divided become two cases. As a case 1 water which phytoplankton dominantly affect the Rrs, while case 2 water many substances affect the Rrs shape. However, many approaches have been developed to retrieve ocean optical properties in case 2 water was not always successful due to the complexity.

In this study, we would like to classify satellite data product using spectrum matching and the look-up table approach rely on matching the measured reflectance with a library of simulated references corresponding to wide ranges of water properties. We try to develop library of simulated in-situ bio-optical dataset from wide range dataset of water properties in case 1 and case 2 water. Dataset was taken from NOMAD dataset [*Werdell, P.J. and S.W. Bailey*, 2005], IOCCG dataset, and in-situ measurement from Tokyo Bay, Kasumigaura Lake, Biwa Lake, Seto Inland, and Thailand Bay in 2002 till 2019. From these datasets, specific inherent optical properties (SIOPs) is calculated then clustered using hierarchical clustering method. From each cluster class average value, we will simulate the remote sensing reflectance using bio-optical model. Increments of 2.0 mgm^{-3}, 2.0 $g\ m^{-3}$, and 2.0 m^{-1} will be used for Chla, NAP and CDOM concentrations, respectively. As the result, this data may become basic look up table for more specific classification of water cases.

Furthermore, ocean satellite data product derivation, remote sensing reflectance could be matched by spectrum matching based on this library then classified based on the nearest cluster.

Effects of ancillary meteorological data on Rayleigh-corrected Top of the Atmosphere reflectance using GOCI data

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The most appropriate choice among ancillary meteorological datasets for atmospheric correction of Geostationary Ocean Color Imager (GOCI) data is needed when producing satellite-derived products with science quality. For example, an ancillary dataset requires 10m wind speed and sea-level pressure for the meteorological variable, and precipitable water vapor for concentrations of atmospheric gases. Among the potential sources, Korea Ocean Satellite Center (KOSC) in Korea Institute of Ocean Science and Technology (KIOST) also used NCEP/NCAR reanalysis-2 (hereafter NCEP) as an ancillary meteorological data when producing GOCI products. Unfortunately, if NCEP is not available, its monthly climatology is used. Here, the meteorological inputs required from reanalysis are wind speed at 10 meters above the sea surface (or 10m wind speed), sea-level pressure, and total precipitable water vapor (or precipitable water vapor). Recently, a new version of reanalysis, ERA5, has been released with a better resolution, better model schemes, and more various assimilation of observation, but most of the atmospheric correction is used for climatology or earlier versions of reanalyses (e.g., ERA-interim and NCEP). Because the choice of different reanalysis datasets could generate different satellite-derived products, the primary goals are to quantify the accuracy of reanalyses and to evaluate the effects of them on the Rayleigh-corrected top of the atmosphere (TOA) reflectance (R_{rc}) using GOCI data.

As a result of reanalyses assessments, we provide a ranking of the ancillary dataset by the statistical parameters such as mean bias error (MBE) and root mean squared error (RMSE) of 10m wind speed, sea level pressure, and total precipitable water vapor. Through ranking values, the largest and smallest value represent the worst and best dataset, when compared to observation, including KMA-buoy and IGRAv2, respectively. In particular, ERA5 shows the smallest spread of errors compared to the others, whereas climatology consistently shows the largest errors in each variable through the statistical parameters. Although NCEP is approximately as good as ERA5 for the two variables of sea level pressure and total precipitable water vapor, NCEP overestimated for the synoptic-scale variations in wind speed variables observed around the Korean Peninsula. Thus, ERA5 was the best, followed by NCEP, while climatology was the worst.

Data Service Environment (DSE) for GOCI-II ground segment

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Geostationary Ocean Color Imager-II (GOCI-II) will be launched at March 2020. After In-Orbit Test (IOT) for GOCI-II, Korea Ocean Satellite Center (KOSC) in Korea Institute of Ocean Science and Technology (KIOST) will provide the Level-1B and -2 data from the end of next year. Therefore, KOSC has developed the Data Service Environment (DSE) to facilitate the distribution of GOCI-II data. DSE supports a convenient system for distributing GOCI-II data and collecting ancillary data for GOCI-II data processing. Users will be able to download the data of Network Common Data Form 4 (NetCDF4) format and the data with the user-defined regions of their interest. DSE contains 3 kinds of modules: data management, data distribution, and external data collection modules. Data management module records log of GOCI-II data collection and distribution. Data distribution module plays a role to transfer GOCI-II data from the server to the end users. Lastly, external data collection module collects meteorological data for performing atmospheric collection and ancillary data for conducting geometric correction. We believe that GOCI-II data will be serviced to end users form around the world by using DSE.